

ART. XVIII.—*The Physical Features of the Australian Alps.*

BY JAMES STIRLING.

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(WITH DIAGRAMS.)

ARTICLE 1.—THE MITTA SOURCE BASIN.

INTRODUCTORY.

INTERSECTED by the 37th parallel of south latitude and by the 147th and 148th meridians of east longitude is situate a tract of mountainous country, which has not been inaptly called the Alpine regions of Victoria, exhibiting a polymorphic variety of physical features at once interesting and instructive—an area within which are situated the highest elevations of the Victorian Cordillera, lofty peaks and elevated snow-clad plateaux (the latter connected to the main range by ridges of varying width and surface contour), amid whose perennial springs most of the principal streams flowing into the Gippsland lakes on the south and the Murray River on the north find their sources. The general trend of the Dividing Range is here north-easterly, and the different source basins it divides are the Indi, Mitta Mitta, Kiewa, and Ovens, flowing northerly, and the Buchan, Tambo, Mitchell, and Macalister, flowing southerly. Owing to their elevation, the more prominent peaks and plateaux are annually covered with snow, which does not melt from their southern and more shaded slopes for many months of the year; and those heights which exceed 6000 feet above sea level are devoid of shrub vegetation. The greater part of the Dividing Range, however, is covered with a vigorous growth of vegetation, principally eucalypts, with undergrowth scrub (thickly growing olearias, pomaderris, Lomatias bedfordias, and other well-known arboreous shrubs), most luxuriant amid the heads of those gullies starting from the southern side of the range. The conformation of the Dividing Range is not that of an anticlinal ridge throughout, but presents a diversity of contour, rising into dome-shaped

heights, as at Mount Hotham (6100 feet above sea level); opening out into flat expanse of tablelands at lower levels, as Paw Paw and Precipice Plains (5300 feet); descending into low gaps, as Tongio Gap, near Omeo (3000 feet), thus affording an easier access from the northern basins to the sea-board; and again rising into rugged and serrated mountains, as the Cobberas (6025 feet). The tablelands north of the Divide are Bogong High Plains (6000 feet) and the Omeo Plains (3000 feet); and south of it are the Snowy Plains (about 5000 feet), Dargo High Plains (5000 feet), and the Nuninyong and Gelantipy tablelands, each over 3000 feet above sea level. The physical features of the higher plateaux are distinctively Alpine—flat expanses of moorland and undulating rises, covered with Alpine flowers and snow grasses; mosses and lichens, at the sources of springs, and groups of gnarled and stunted gum scrub on the lower lying shelves. Although the surface is rocky in parts, the soil, a rich volcanic, is highly productive, and during midsummer (about the beginning of February) these highlands are covered with a most luxuriant verdure, the richness and softness of which is hardly conceivable by those who have not seen similar localities. The bright, emerald-tinted carpeting of the snow grasses, with crystal streams (small source runnels) traversing the area, make a most striking contrast to the brown and parched appearance of the lower lands and valleys, literally languishing in excessive dryness at this season of the year. The grandeur and sublimity of the surrounding scenery—seas of mountains rising, wave-like, on every side, presenting almost infinite shades of blue and purple colouring, the extreme rarity of the air, and other conditions which lend an additional charm to the landscape—leave an impression on the mind of the beholder not easily effaced. Although these highlands form excellent summer pasturages, upon which stock fatten rapidly, so rich and nutritive is the herbage, yet, owing to severe frosts, snow, and sudden climatic changes, they are for the greater part of the year perfectly inhospitable. Snow frequently falls to a depth of 12 feet in these regions, and, where at all shaded from the sun's direct rays, remains throughout the entire summer, forming young glaciers, which, however, never mature, owing to variations in summer temperature, to which even these elevated regions are subject.

In close proximity to one of these plateaux (Bogong High Plains) the highest peaks in the colony are situated—

notably Mount Bogong, 6508 feet at its northern extremity; Mount Cope, 6015 feet at its eastern rim; and Mount Feathertop, 6303 feet at the south-west margin. The Main Dividing Range, as at present existing, is not an original axis of elevation, but, on the contrary, has assumed its present position by a long-continued process of denudation and erosion from a once extensive highland existing during miocene time, and of which such peaks as Mount Wills and Mount Gibbo north of it, and Black Mountain, Mounts Bindi, Baldhead, and Wellington south of it, are some of the remaining representatives. Some of the evidences of this ancient highland are found in localities now occupied by coatings of basalt, overlying miocene flora resting on Silurian rocks, some of the present river valleys having eroded their courses along the margin of these lava flows, leaving the height of the underlying strata and the depth of the basaltic coating plainly discernible. Such a case is noticeable at Mount Tabletop, along whose margin the deeply eroded valley of the Dargo River passes, leaving this isolated patch of basalt as a connecting link between the partially denuded coatings on the Bogong and Dargo high plains. The numerous igneous dykes* traversing the metamorphic schists along the valley of the Livingstone Creek (admitting their contemporaneousness with the lava flows existing on the higher elevations) seem also to me to point to a period of higher elevation than at present exists, the igneous dykes being the undenuded portions of an ancient lava flow covering the then existing miocene plateaux.

The present elevated plateaux, as might be expected, form the gathering grounds of most of the principal streams. The Omeo Plains tableland, however, is a noticeable exception to this. Covering an area of 24 square miles, this depressed tableland has a small lake in its centre, $3\frac{1}{2}$ miles long by $1\frac{1}{2}$ wide, which is fed by rains and the storm-waters from the surrounding hills. It has no visible outlet, the character of the country surrounding it consisting of open, treeless plains, merging by gentle slopes into the encircling timbered ranges.

Owing to the proximity of the coast line, about 49 miles

* There are two sets of igneous dykes within the area, the one intrusive from deep-seated sources, the other as indicated—probable remnants of surface lava flows.

distant from the most southern prolongation of the Dividing Range, at the head of the Livingstone Creek, and probably to the degrading and eroding influence of southerly and south-westerly moisture-laden winds, the southern slopes are steeper than those within the northern basins. This is more especially the case with the Mitchell and Mitta Mitta basins, the former having a more rugged and serrated surface configuration than the latter, which is more undulating and rounded.

Recent observations made by me at Omeo for Mr. Ellery, when compared with records of rainfall at Grant, which is in the centre of the Mitchell basin, give interesting results, at Omeo that for 1880 being 29·92 inches during 114 days, and for same period at Grant 58·59 inches during 154 days. This difference of 38·67 inches, although slightly affected by elevation (Grant being 3700 feet above sea level, and Omeo 2108 feet), is, I think, still due to the following causes:— That as the principal rainfall at Omeo is brought by southerly and south-westerly winds from the Southern Ocean, these moisture-laden winds are deprived of their aqueous matter by condensation south of and along the crest of the Dividing Range, and are then raised into the higher regions of the atmosphere, from which they are attracted by the higher peaks and plateaux; there, by the action of colder currents of air or electric forces, re-condensed, and deposited in the form of snow. Were the surface within the Mitta Mitta basin as much subjected to the action of heavy deluges of rain as that of the Mitchell appears to be, it is probable that the river valleys of the former would be more deeply cut into gorges by erosion, and the peaks present a more splintery outline than they do at present, owing, in a great measure, to the petrological characteristics of the area—crystalline schists, which, as I understand, have a tendency to weather into sharper outlines than their unaltered congeners, the Silurian rock masses occurring in the Mitchell basin. If this view be correct, the undulating and rounded outlines of the ranges within the Mitta Mitta basin would probably result from the more gradual disintegration of the rock masses by frosts and snows. The more important characteristics of the source basins comprised within the area indicated at the commencement of this paper are as follows:—The Indi, although unimportant commercially, is still interesting from a topographical and geological point of view. Forming the head waters of the Murray River, some of its

eastern affluents find their sources amid the perennial springs issuing from the highest of our Australian Alps, Mount Kosciusko. One of these affluents, the Pilot River (rising at Mount Pilot, 6020 feet, a coned peak), has deposits of stream tin on its upper courses now being tested. Several of the western affluents are auriferous; while its most southern affluent, the Limestone Creek, runs through a patch of crystalline (marbleiferous) limestone of Devonian age, on which are situated some fine caves, the stalactites being more pearly and translucent than any others I have seen in the colony, while the calcitic crystals which line the sides of the caverns are exceedingly beautiful in appearance.

The Mitta Mitta source basin (the subject of this paper) has not only the greatest surface diversity, but supports the largest population—mining, pastoral, and agricultural—scattered over its area. Within it is situate the Omeo township and its gold workings along the Livingstone Creek, the Omeo Plains agricultural settlement, the gold workings at head of the Gibbo River and at Wombat Creek.

The Tambo source basin has also pastoral, mining, and agricultural operations carried on within its area, quartz and alluvial mining on its western affluent, Swift's Creek, and an agricultural settlement at Bindi, situate on a patch of fossiliferous limestone of Middle Devonian age, intersected by an eastern affluent, Bindi Creek.

The Mitchell source basin has principally mining and pastoral interests within its area. Its northern affluent, the Dargo River, rising at the Divide near Mount Hotham, and draining the Dargo High Plains, has a patch of open, undulating granite country, and some rich alluvial flats, a short distance above its junction with the parent stream. On the latter flats is situated the Dargo settlement, where sufficient agricultural and dairy produce is raised to supply the elevated mining township of Grant, and the quartz mining operations being carried on in the surrounding hills. A western affluent—the Wonnangatta—finds its principal sources in the Snowy Plains tableland.

The delineation of this source basin, with the more important geological and botanical characteristics, will, I trust, form the subject-matter of a subsequent paper.

DETAILED TOPOGRAPHY OF THE MITTA MITTA SOURCE BASIN.

The heads under which I propose to delineate this area (enclosed with red lines on feature-map presented with this paper) are—(1) Its topography; (2) geological structure; (3) botany, or vegetation. To give even a fair outline in each of these subjects would occupy more time than is allowed for the reading of this paper, so that, for the present, I shall confine my observations to its surface configuration, or topography. The area under consideration embraces fully 1050 square miles of territory, made up of the following drainage areas :—

1. Southern affluents	}	Livingstone Creek, 138 square miles.			
		Victoria River	81	"	"
2. Western affluents	}	Cobungra River	98	"	"
		Bundarah River	65	"	"
		Big River	160	"	"
3. Eastern affluents	}	Wombat Creek	61	"	"
		Benambra Creek	233	"	"
		Gibbo River	112	"	"
Mitta Mitta, between Cobungra and Big Rivers			78	"	"
Omeo Lake drainage area		24	"	"

Owing to the western affluents draining the Bogong High Plains, and to the general altitude of the western watershed line, the volume of water brought down by these affluents constitutes the principal source supply of the Mitta Mitta. And, as an instance of the effect which the higher plateaux have in regard to the collecting capacity of a source basin, it is interesting to note that, although the Victoria River only drains an area of a little more than half as much as the Livingstone Creek, yet the former empties almost as great (if not quite as great) a volume of water into its recipient, the Cobungra, as the latter does into its recipient, the Mitta Mitta; the Victoria rising at the Paw-Paw Plains, and draining those tablelands, over 5000 feet above sea level, while the highest point drained by the Livingstone Creek hardly exceeds 4000 feet.

Taking into consideration, first, the physical conformation of the western watershed line which intersects the highest plateau, the Bogong High Plains, we find it starting from Mount Hotham, on the Dividing Range (at a much lower level than that height), as a well-defined, narrow ridge, separating

the Kiewa sources on the west from the Cobungra on the east. Rising two miles distant to almost a level with the latter mountain, it again depresses fully 2000 feet, and again rises towards the rim of the basaltic coating constituting the Bogong High Plains.

The highest elevation of these plains covers an area of seven square miles, and in it the Cobungra on the south, the Bundara on the east, and the Kiewa on the west, find their sources. From the eastern slopes the watershed line proceeds by easy undulations to Mount Cope (a coned peak), distant about $9\frac{1}{2}$ miles from Mount Hotham. From thence the watershed line traverses a rugged surfaced plateau in a northerly direction towards Mount Bogong; rising into rounded heights devoid of shrub vegetation; stretching into moorland flats; forming into rolling, rocky-crested ridges; narrowing into sharp razor backs, where the source runnels of the different streams interlace each other; and again forming gentle grassy slopes, until at a point about five miles south of Mount Bogong these highlands give place (at a much lower level) to a narrow, serrated ridge, so rocky and sinuated as to render the ascent of the mountain difficult even on foot. The head waters of the Big River skirt this narrow ridge, and wash the base of Mount Bogong (a granite mountain), while the western affluents of Kiewa have sculptured the steep western slopes of this important mountain, the distance between it and Mount Hotham being about twenty miles. From this point the main watershed line between the Kiewa and Mitta Mitta proceeds northerly, forming first a series of rugged surfaced plateaux similar to those south of the mountain, and then forms a distinct anticlinal ridge, descending in elevation towards the Murray flats. South-easterly a minor watershed line, forming a high range, separating the Snowy Creek on the north from the Big River on the south, proceeds to Mount Wills (a bold peak, 5758 feet, having huge escarpments of rock on its eastern face); from thence two ridges radiate, encircling Wombat Creek, the most northerly one forming a finely outlined range, on which are situated Mounts Martin and Cooper, important landmarks on the road between Omeo and the lower Mitta Mitta.

The general configuration of the minor watershed lines dividing the western affluents is that of gradually sloping terraces and shelves, open grassy flats, with thickly timbered rises, occasionally rocky (the timber taller than that on the

higher plateaux). The steepest slopes prevail on the southern side of the watershed lines, being frequently precipitous. This peculiarity of the east and west streams seems to me to be in a measure due to the influence of the prevailing southerly winds driving the surface currents of these streams on to their northern banks, and the latter being rocky would cause the streams to gradually wear away towards the north, eating under the rocky cliffs. However, this is merely an opinion, open to objection, as there are so many causes at work by gradual operations, extending over great periods of time, that it would be indeed difficult to form a positive opinion, even as to the proximate causes which led to this peculiar characteristic of these streams. Possibly meteorological conditions during the past may have been more powerful than at present, causing more extensive denudation of the then surface, and eroding the courses of streams in directions which the then existing composition and position of the rocky strata have exercised an important influence in maintaining since that period. Owing to the rapid fall of most of these western affluents they have become eroded down to the bed rock, except in those places where hard bars of gneissose rocks or igneous dykes cross the streams, and by longer resisting the abrading forces of the water have formed above them deep troughs, into which a gravelly wash becomes settled. These deposits are frequently auriferous, and have been worked for gold.

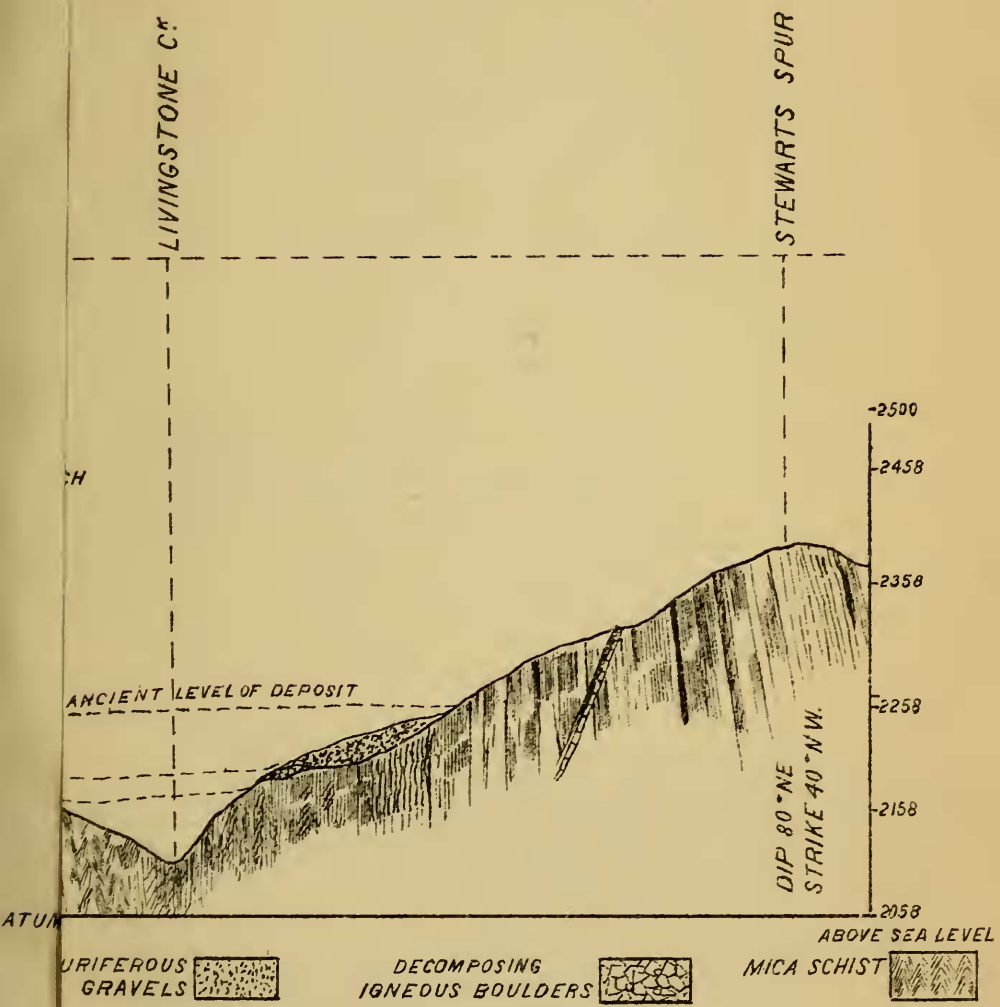
The southern affluents, the Livingstone Creek and Victoria River, are partly encircled by the Main Dividing Range, the character of the country along their courses being much more open and undulating than the principal tracts of country intersected by the western affluents; in fact, almost the whole course of the Livingstone and the greater part of the Victoria includes rich pasture lands, more open and gently undulating along the eastern and south-eastern watersheds of these streams—the former comprising the rolling pasture hills stretching from Omeo township towards Tongio Gap, and north-easterly towards the Omeo Plains, and the latter the still more open and gentle grassy slopes of Parslow's Plains.

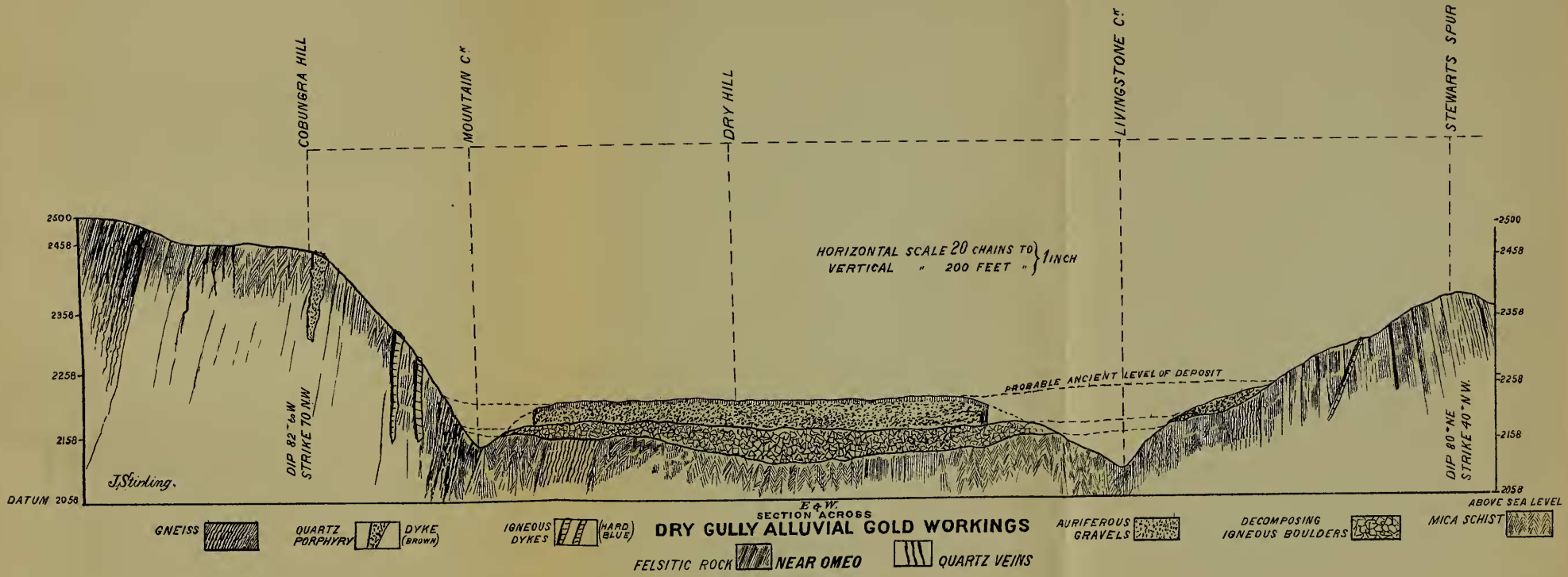
The physical conformation of the Divide where it forms the watershed line of these streams is, first, a rather flat expanse of tableland—Paw Paw and Precipice Plains (the south-western edge of these plains being precipitous where the Dargo River valley skirts it); it then depresses some-

what, and again forming an anticlinal ridge towards Mount Phipps, a flat-topped, thickly-timbered height some 16 miles distant, and about 4300 feet above sea level.

An extension of the Precipice Plain tableland forms the watershed line between the Victoria and Cobungra, the surface configuration being a mere modification of that on the higher plateaux. From Mount Phipps a minor watershed line trends north-easterly in a rather circuitous direction towards Mount Livingstone (a rounded height near Omeo), and separating the Victoria River from the Livingstone Creek; while southerly from the former mountain the Main Divide forms an elliptical curve, enclosing the extreme southerly sources of the latter creek. Continuing thence as a well-defined ridge, it suddenly breaks away along the eastern watershed of that creek into two low gaps—Swift's Creek and Tongio Gap—the latter forming the principal (and natural) outlet from the Mitta Mitta source basin to the seaboard (*viâ* the valley of the Tambo River). From Tongio Gap the country slopes gradually towards the Omeo township (five miles distant), while southerly it falls away into a deep gorge formed by the valley of the Tambo.

From this gap the Dividing Range forms a clearly outlined anticlinal range, northerly towards Mount Sisters, at the eastern margin of the Omeo Plains tableland (ten miles distant). Within the Livingstone drainage area is situated the township of Omeo; its actual position, $37^{\circ} 06' S.$ lat., and $147^{\circ} 26' E.$ long., at an elevation of 2108 feet above sea level. It enjoys a mean annual temperature of about 50° Fahrenheit; a climate both salubrious and exhilarating, its greatest summer heat being tempered by cooling mountain breezes, while the winter's snow seldom remains longer in the immediate vicinity of the township than a few days. The Omeo goldfield, although one of the oldest in the colony, remains at present practically undeveloped. An important feature connected with the auriferous deposits near Omeo consists in their situation. Occupying the valley of the Livingstone Creek, since the lower Silurian rocks became metamorphosed into the present crystalline schists, were a series of ancient lakes, or tarns, into which, by the breaking-up of the ancient lava flows, masses of igneous boulders became deposited; subsequently the gradual wearing down of the metamorphic schists, with their associated auriferous quartz veins, filled up these ancient lake-beds with a deposit of





boulders and auriferous gravels. Ultimately the Livingstone Creek (instead of wearing a passage through the centre of the area so filled in) eroded a channel along its margin, leaving the deposited gravels, with their underlying false bottom of igneous boulders, literally high and dry above the present bed of the latter stream. At Dry Gully, near Omeo (a section of which I give), these auriferous gravels have been worked profitably, by sluicing operations, for gold during the past twenty years, and are now profitably worked.

A recent discovery of rich quartz reefs on the hills *in situ* is likely to prove deeply interesting, both from a mining and geological point of view. The character of the rocks in which these reefs exist may be briefly described as intercalated bands of gneissose, micaceous, and quartzitic schists (strike, 70° N.W.; dip, 80° S.W.), intersected by hard blue igneous dykes and bands of brownish quartz porphyry (the latter apparently not descending more than 200 feet below the surface).

The reefs run in a general northerly direction, varying from 20° N.E. to 10° N.W., with a dip of about 60° to S.W.* An interesting problem that is likely to be opened out by the working of these reefs (independently of the rich field for observation in a study of the interrelations of these altered rock masses) consists in the question whether these auriferous reefs existed as such in the Silurian strata prior to its metamorphism into crystalline schists, as the result of aqueous solution, or whether they are derived by gaseous sublimation from the rock masses during the process of metamorphism, whether by hydro-plutonic causes or otherwise. As I find, by observation, these metamorphic schists are here corrugated parallel to the line of strike, it seems feasible that reefs, if existing prior to the action of the forces producing the corrugations, would be exceedingly twisted and contorted along their line of strike. However, these are questions outside the limits of this paper, and which properly come within the scope of an inquiry into the geological structure of the area.

Returning to Mount Sisters, at the margin of the Omeo Plains, we note a low rolling ridge of pasture hills, separating

* Since writing the above, a number of claims have been opened out, showing a dip of 60° to E; strike still northerly.

the undulating ranges near Omeo from the Omeo Lake basin drainage area.

Of the 15,360 acres constituting the latter, fully 14,000 are now occupied for agricultural purposes. Another open ridge (consisting of a series of cone-shaped hillocks, whose bases merge into the open plains on either side) separates the Omeo Lake area from the Benambra Creek catchment basin, thus dividing the whole of the plains into two portions. From Mount Sisters the Dividing Range is well defined, rising at Mount Tambo, five miles distant, to 4700 feet (the latter a mass of purple conglomerates, resting on sandstone of Devonian age); it depresses somewhat, and again rises towards a rounded granitic peak (Mount Leinster, near the head of the Tambo River). From thence it winds in a general north-easterly direction to Mount Cobberas, the Pilot, and Mount Kosciusko (the culminating point in the range), at an elevation of 7256 feet above sea level. The eastern watershed of the Mitta Mitta—*i.e.*, of its eastern affluents—comprises a high, well-defined range, which, starting from a point on the Dividing Range midway between Mounts Tambo and Cobberas (at the extreme northerly source of the Tambo River), proceeds northerly, finding its highest elevation at Mount Gibbo (a coned peak 5764 feet above sea level), and divides the head waters of the Benambra Creek and its tributary, Mount Leinster Creek, from the Indi River. From Mount Gibbo a number of watershed lines radiate in a northerly direction; a minor watershed line, forming the northern watershed of the Gibbo River, terminates in a prominent peak—Toaks Gibbo—near the Mitta Mitta River. Of the streams forming the eastern affluents of the Mitta Mitta, the Benambra Creek is the most important, embracing an area of 233 square miles, its upper courses opening out into some fine open upland flats, marsh lands now partially drained, consisting of flats averaging one mile in width, treeless, except on their margins, of which I give sketch.

The ridiculous reports as to the unexampled severity of the frosts on these fertile uplands has to a certain extent militated against their settlement. However, from the Omeo Plains as a centre, settlement is slowly extending along these upland tracts. Only so far back as 1875 the Omeo Plains were reported to be inhospitable, and unfit for agriculture, owing to climatic causes, although the richness of the soil was admitted; now they are completely occupied by a